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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These proceedings summarize the relevant presentations and discussions of the national science advisory meeting held on March 28-30, 2017 at the Lord Elgin Hotel in Ottawa, Ontario. The conclusions and advice resulting from this meeting will be provided in the form of a Science Advisory Report that will be made publicly available on the CSAS website. Meeting participants included experts from various sectors and regions of Fisheries and Oceans Canada, as well as external participants from Canadian Healthy Oceans Network (CHONe), University of Quebec, and Cape Breton University. The purpose of this meeting was to assess the feasibility of determining benchmarks of fish productivity in marine ecosystems, including relevant methodologies and spatial units of variability. Once developed, regional productivity benchmarks are anticipated to be used to provide estimates for understanding impact assessments and facilitate the estimation of targets of potential gains in productivity expected from offsetting. Two working papers were distributed to the participants and reviewers. The first paper examined regional benchmarks of fish productivity in nearshore marine ecosystems was reviewed at the meeting for publication as a Research Document. The second paper, on fish production metrics from a nursery area in the marine coastal zone of Newfoundland, was presented to facilitate discussions at the meeting and participants were asked to provide written feedback afterwards for consideration as a Research Document.

SOMMAIRE

Le présent compte rendu résume les présentations et les discussions pertinentes de la réunion de consultation scientifique nationale qui s'est déroulée du 28 au 30 mars 2017 à l'hôtel Lord Elgin, Ottawa (Ontario). Les conclusions et avis qui découlent de cette réunion seront présentés sous forme d'avis scientifique qui sera rendu public sur le site Web du Secrétariat canadien de consultation scientifique (SCCS). Des experts de divers secteurs et de diverses régions de Pêches et Océans Canada ont participé à la réunion, de même que des intervenants extérieurs, provenant du Réseau stratégique pour des océans canadiens en santé (CHONe), de l'Université du Québec et de l'Université du Cap-Breton. Cette réunion avait pour objet d'évaluer la faisabilité de déterminer les points de référence de la productivité du poisson dans les écosystèmes marins, y compris les méthodes pertinentes et les unités spatiales de variabilité. Une fois élaborés, on prévoit utiliser les points de référence de la productivité régionale pour établir des estimations aux fins d'évaluation de l'impact et pour établir des objectifs raisonnables de gains potentiels de productivité attendue des projets de compensation. Deux documents de travail ont été distribués aux participants et aux analystes. Le premier document, portant sur les points de référence de la productivité du poisson dans les écosystèmes côtiers, a été examiné à la réunion aux fins de publication comme document de recherche. Le second document, portant sur les paramètres de production du poisson d'une aire de croissance dans la zone marine côtière de Terre-Neuve-et-Labrador, a été présenté pour faciliter les discussions à la réunion, et les participants étaient invités à fournir par la suite leurs commentaires par écrit afin qu'ils fassent partie d'un document de recherche.

INTRODUCTION

Keith Clarke and Mike Bradford (co-chairs) opened the meeting by welcoming the participants, providing a brief overview of the Canadian Science Advisory Secretariat (CSAS) peer-review process, and requesting that everyone consider, throughout the course of the meeting, whether there are any common aspects between the papers and how science advice can be extracted from the discussions of the meeting. The Terms of Reference (Appendix 1) indicated that the purpose of the meeting was to collect and provide scientific advice on the feasibility of determining benchmarks of fish productivity in marine ecosystems for the Fisheries Protection Program (FPP). In order to accomplish this, two papers were discussed that examined regional benchmarks of fish productivity in nearshore marine ecosystems and fish production metrics in a nursery area in the marine coastal zone of Newfoundland. Participants included members from a variety of divisions of Fisheries and Oceans Canada (DFO), as well as the Canadian Healthy Oceans Network (CHONe), University of Quebec, and Cape Breton University (Appendix 2). The co-chairs reviewed the agenda (Appendix 3), discussed deadlines for the expected publications, and verbally determined that there was consensus for the Terms of Reference.

An overview of the *Fisheries Act* and the FPP was presented to provide context for the request for advice. A discussion followed about how management tools may be improved and used operationally.

DETERMINING FRESHWATER REGIONAL BENCHMARKS OF FISH PRODUCTIVITY

Co-authors: Robert G. Randall, M.J. Bradford, D.T. de Kerckhove, and A. van der Lee

Presented by: Robert G. Randall

SYNOPSIS OF PRESENTATION

The presenter reviewed a previously published Research Document (Randall *et al.*, 2017) and highlighted information included in a previous Science Advisory Report (SAR) on regional productivity benchmarks (DFO, 2016b). The authors examined the feasibility of using electrofishing data to determine regional benchmarks through a 'proof of concept' approach. This strategy was divided into three objectives:

- Summarize fish biomass density of the survey area and determine the feasibility of using electrofishing data to quantify regional differences.
- Determine regional differences in fish density-body size relationships.
- Evaluate habitat carrying capacity using population and community biomass as well as temperature according to the Metabolic Theory of Ecology.

Electrofishing data from 15 regions across Newfoundland, Nova Scotia, New Brunswick, Ontario, Alberta and British Columbia were collated. Three representative datasets were presented in more detail: Terra Nova National Park in Newfoundland, Margaree River in Nova Scotia, and Magpie and Batchawana Rivers in Ontario.

A habitat productivity index (HPI) was developed for each site using density-body size relationships. For the majority of species, average biomass densities had significant positive relationships with air temperature at both the community and species levels. Both average fish biomass density and HPI were consistent with the literature, however, further examination was recommended. Results also examined community and species-specific relationships between density and body size. The presenter outlined several challenges of using existing data:

- Difficulty in identifying ecosystem carrying capacity if the habitat is degraded or contains migratory or depleted species.
- A lack of data in some areas.
- Uncertainty associated with capture probability.
- Inconsistent sampling protocols among datasets.

Overall, the results demonstrated that productivity varied significantly and predictively between regions. The presenter recommended the use of literature values of allometry as opposed to the density-body size relationships, which were inconsistent regionally. Suggestions for future work included establishing a national database for electrofishing, undertaking a science review of catch probability, and examining alternative boundaries to Fisheries Management Zones. In summary, the presenter concluded that it was feasible to use electrofishing data to create regional benchmarks in specific conditions. Possible uses for benchmarks included incorporation into offsetting programs, evaluation of project impacts, facilitation of tracking cumulative effects, and application in data deficient environments.

DISCUSSION

Participants requested clarification on the differences between benchmarks used in marine ecosystems versus freshwater ecosystems. Challenges associated with using benchmarks in the marine environment included difficulty in measuring the density of migratory/exploited stocks, and the frequency at which they use a habitat. The presenter agreed that some inferences about habitat use must be made for fish species known to inhabit an area for a short time (e.g., two weeks), as those habitats will make some contribution to productivity.

The presenter explained that all datasets took capture probability into account and data was adjusted accordingly. Additionally, uncertainty associated with catch efficiency was acknowledged for a subset of the data.

Participants discussed that, in addition to temperature, other important criteria for the operational use of the Metabolic Theory were water chemistry (e.g., nutrients and conductivity), and landscape attributes (e.g., forest and farmland cover, geology).

There was further discussion on the possibility of reducing variance by categorizing the datasets according to the level of human impact. The presenter agreed that categories are preferred by management, and attempts to categorize data would be valuable.

Clarification was required on the distinction between habitat carrying capacity and regional benchmarks of productivity.

A participant suggested that threshold effects, often underused in management approaches, should be considered when identifying regional boundaries.

TOWARDS REGIONAL BENCHMARKS OF FISH PRODUCTIVITY IN NEARSHORE MARINE ECOSYSTEMS: MODEL FRAMEWORK, HABITAT COMPARISONS, AND EXAMINATION OF REGIONAL DATA

Co-authors: Melisa C. Wong and M. Dowd

Presented by: Melisa C. Wong

SYNOPSIS OF PRESENTATION

In preparation for publication as a Research Document, this working paper was reviewed at the meeting. The lead author presented the research on the development of regional benchmarks of fish productivity in nearshore habitats (i.e., eelgrass, soft sediment, rocky reefs). There were common challenges with estimating nearshore fish productivity:

- Limited data on body size or life history.
- A lack of comprehensive time series analyses.
- Difficulty in estimating production from stock assessments.
- Difficulty in quantifying habitat use by nearshore fish.

There were five research objectives:

- Development of a model framework that estimated lifetime productivity in data poor environments.
- Application of the model to valuable habitat on the Atlantic coast of Nova Scotia.
- Use of the model outputs (i.e., species specific abundance, biomass, and production per age class) to compute three metrics of production relevant for FPP (i.e., production potential, equivalent adults, and area per recruit (APR)).
- Evaluation of the relative importance of habitat types.
- Summarization of regional data and its use in developing benchmarks.

The model was assembled as a Leslie matrix from an age-structured population. Model inputs included observed species-specific densities of at least one age class, and literature values for survival and length-weight growth functions. As a result of limited data, it was assumed that populations were in steady-state. Uncertainty estimates were calculated using Monte Carlo simulations accounting for parameter dependence.

The model was applied to data collected in Nova Scotia from eelgrass beds, rockweed beds, and adjacent sediment sites. Data was calibrated based on the sampling methods used, including fyke nets, beam trawls, and snorkel transects. Results showed that habitats with biogenic structure (i.e., containing eelgrass or rockweed) enhanced both production potential and adult equivalent abundance for most species, relative to unstructured habitat, particularly for many commercial, recreational or Aboriginal (CRA) fish species. Additionally, APR analyses showed that marine species required more area (i.e., 1 to10^6 m^2) than freshwater species (i.e., 100 to 1000 m^2) however slightly different methods were used to calculate APR for marine and freshwater environments which affected results. Additional datasets from the southern Gulf of St. Lawrence were examined, however, they were found to be not in a form suitable for use in the model. The presenter highlighted that this model was comprehensive, useful for field data as it accounted for all life stages, and was sufficiently general and flexible for data poor environments.

DISCUSSION

Participants required clarification on the sampling methods and calibrations used. For example, an inquiry was made to identify the reasons for selecting the different sampling gear types for the field data collection. The presenter explained that using different methods allowed for comparisons thus facilitating data calibrations. Furthermore, certain gear types were more effective in different habitat types (e.g., fyke nets in eelgrass). Additionally, participants and the lead author agreed that detection modelling should be conducted for each sampling method, specifically for snorkelling transects.

A participant asked about challenges with estimating year class composition of certain species (e.g., stickleback). The presenter explained how regional knowledge and literature values were used to estimate size at each age class. Age estimates were most difficult for adult fish but most individuals were aged 0-1.

Clarification was requested to better understand the proportion of CRA fish species that were captured in the model. It was agreed that an economic evaluation of CRA species in these habitats should be conducted.

Participants discussed the inclusion of historic baseline data and reference points (i.e., from stock status reports) to help interpret APR values. For example, high APR values may indicate that habitat was either not ecologically relevant for a species or certain species were depleted at the time of sampling.

Discussions followed on the challenges of estimating productivity for freshwater species in contrast with marine species (e.g., marine species frequently move between habitats), model application in other regions and situations (e.g., aquaculture), and expansion of the model for use with other taxonomic groups (e.g., shellfish). It was agreed that this model was extendable for use in other habitats and on other species not examined in the working paper.

FISH PRODUCTION METRICS FROM A NURSERY AREA IN THE MARINE COASTAL ZONE OF NEWFOUNDLAND

Co-authors: Robert S. Gregory, B.J. Laurel, D. Coté, B.H. Newton, K.L. Dalley, P.S. Sargent, P.V.R. Snelgrove, K.D. Clarke, and M.C. Wong.

Presented by: Robert S. Gregory

SYNOPSIS OF PRESENTATION

This presentation was accompanied by a working paper. In preparation for potential publication as a Research Document, participants were asked to provide written feedback after the meeting. Seven multi-year datasets were used to examine fish production in nursery habitat located in Newman Sound on the northeast Newfoundland coast. These datasets included information on juvenile and nursery production, habitat distribution, and oceanographic variability. The presentation focused on the 21 year dataset from Newman Sound, where abundance of Atlantic cod (*Gadus morhua*) and other fish species were sampled biweekly at 6-13 sites between July and November from 1995 to 2015. Cod, aged 0 and 1, were caught via beach seine, counted, and measured. Cod, aged 0, settled into several different recruitment pulses each year (i.e., based on which month they hatched). The presenter continued by outlining years of strong and weak cohort and pulse structures. Correlations were presented for cod between different age classes.

The Newman Sound survey also investigated the role of eelgrass (*Zostera marina*) in juvenile cod abundance and habitat use. Eelgrass habitat is very important for cod through the provision of shelter and food during the juvenile stage, when cod are most vulnerable. The authors reviewed past studies on the relationship between juvenile fish and eelgrass habitat, highlighting that several juvenile fish species use eelgrass, juvenile cod abundance fluctuates with the loss and expansion of eelgrass patches, and juvenile cod are approximately 17,000 times more likely to survive 90 days in eelgrass relative to unstructured substrate.

DISCUSSION

Discussions were held on the possibility of using the Newman Sound data to obtain productivity metrics and better understand the relationship between the amount of nursery habitat and offshore recruitment. The lead author explained that several metrics (i.e., equivalent adults and APR) will be obtained using the Wong and Dowd model, and useful analyses of offshore populations will be conducted in the near future.

Participants discussed the value of edge effects with respect to offsetting activities and predator-prey dynamics.

A participant asked how mortality and movement of fish was distinguished in seine surveys. It was clarified that although extensive seining was conducted mortality rate would be investigated in future mark-recapture studies. Participants also discussed how patterns of habitat use have changed over time (e.g., spawning and overwinter locations).

HABITAT SELECTION BY JUVENILE COD IN COASTAL MARINE NURSERIES: THE ROLE OF PISCIVOROUS FISH

Co-authors: Evelyn MacRobert, Robert Gregory, Paul Snelgrove

Presented by: Evelyn MacRobert

SYNOPSIS OF PRESENTATION

This research presentation was not accompanied by a working paper at the time of this meeting. The objective of this study was to understand the distribution of predators and cod (at age 0) in eelgrass habitat. The study was conducted at Newbridge Cove in Newman Sound, Newfoundland. The site was chosen for its isolated location and diversity of habitat types. To investigate distribution of juvenile cod, video transects were sampled using a GoPro from August to October of 2016. Vegetation type (e.g., eelgrass, kelp, green algae) and substrate type (e.g., sand, rock, boulder) were noted. Preliminary results demonstrated that 96% of cod, at age 0, were largely restricted to eelgrass habitat, which was consistent with literature values. Acoustic tagging was used to investigate the distribution of predators (i.e., ten Atlantic cod (age 1), ten Greenland cod, ten cunner, and seven sculpin). Nine receivers with a 500m detection radius were distributed around the study site to allow for triangulation. One map from each predator species was presented in detail. The maps showed that Atlantic cod, at age 1, were located primarily in deeper water but visited eelgrass sites, while Greenland cod spent more time in eelgrass and cunner and sculpin were largely found in deep water. The authors proposed to use this data to create a utilization distribution to determine where each predator species spends 98% of their time.

DISCUSSION

A participant asked whether each map that was presented was representative of the overall trends shown by most individuals of a species. The lead author explained that although the four mapped fish were the only ones analyzed so far, the video analyses identified them to be representative of the local predatory species.

A participant expressed concern that the distributions identified for cunner were not consistent with the literature. The presenter explained that the small size of cunner may be a factor in skewing their distributions.

It was suggested that the authors partition the data by time of day as there was evidence that this variable might have an effect on the presence of fish in shallow water.

Clarification on the accuracy of receiver to receiver communication was requested. The presenter explained that although a range test was conducted for receivers (i.e., to test whether the receivers could detect each other), it was possible that a tagged fish moved outside of the receiver range. It was mentioned that a point-to-point analysis would be conducted to observe how individuals moved over time.

DEVELOPMENT OF ADVICE

OBJECTIVE #1 - FEASIBILITY OF USING ESTIMATES OF FISHERIES PRODUCTIVITY TO DEVELOP BENCHMARKS

Usefulness of proposed Wong and Dowd model and approach

The Wong and Dowd model was discussed and participants acknowledged a number of conclusions:

- The Wong and Dowd approach followed earlier approaches for compensation by estimating the loss of adult production (i.e., abundance, biomass, production) that would occur if nursery habitat was altered or destroyed.
- The model was linear and conservative in that it assumed all fish found in a certain habitat would not be able to complete their life cycle elsewhere and that there were no compensatory processes.
- The model was calibrated on the assumption of steady-state at the time of sampling. This assumption made parameterization of the model possible. Participants agreed that steady-state represented the best possible outcome for a population to establish a true benchmark for management. It was agreed that this term would be clearly defined in the SAR.

As a result of the differences in the trophic levels and dynamics, different productivity metrics were used in the freshwater ecosystems examined at the previous CSAS productivity meeting (DFO 2016b) than in the marine ecosystems considered at this meeting. The Wong and Dowd model presented at this meeting used data, in the form of density estimates per age class, to estimate total lifetime production potential, some of which may result from the use of other habitats for older age classes. This approach avoided biases that could have arisen from estimating production at the time of sampling.

With the reality of sampling populations that may not be in their steady-state, it was noted that future studies must select exemplary populations or habitats that appear undisturbed by human

effects. The model required further refinement before official use by FPP, but the group agreed that it was feasible to develop benchmarks of productivity in marine coastal ecosystems.

Offsetting activities appeared simpler and easier in freshwater ecosystems in contrast to marine ecosystems (e.g., digging a new freshwater channel versus constructing an artificial reef). It was concluded that FPP proponents would be more likely to conduct habitat conversions or improvements in marine ecosystems instead of creating new habitat.

A discussion on the size of the area that should be governed by a benchmark, ensued. It was agreed that eelgrass habitats in the Northumberland Strait would have different benchmarks than the same habitats along the coast of Nova Scotia.

Participants, in general, approved of the Wong and Dowd model presented at the meeting.

Model Input Data

Discussions held by participants on the appropriateness of the data used in the Wong and Dowd model and it was noted that:

- Densities of one age class of fish by habitat type were needed to start the computation.
- Uncertainties in field estimates were incorporated into the analysis. These included both temporal and spatial variability.
- Three issues were raised:
    - Temporal sampling frequency (e.g., seasonal, interannual) was discussed. For example, sampling over the course of a decade would result in data that was more closely representative of the steady-state of a habitat. Arguments were made about the pros and cons of reducing the number of sampling efforts to every five years but increasing their quality in contrast to using volunteer groups to sample every year.
    - Catchability/capture probability calibrations required real species' densities. It was noted that a large number of studies in the primary literature on fisheries can explain how this should be dealt with. Participants suggested that sampling of populations should occur at a time when saturation of the habitat is expected (e.g., late summer in sea grass habitats) in order to obtain the best possible abundance estimate. In consideration of climate change it could be appropriate to use the best temperature at which a species would saturate a habitat. An alternative consideration was to use the season when a species is most vulnerable to sampling gear.
    - Assumption of habitat capacity potential (e.g., limited commercial fish recruitment could cause local habitat to be undervalued). A community may be in an inflated or depleted state at the time of sampling resulting in a possible overestimation or underestimation of habitat productivity.

Wong and Dowd Model Outputs: results and presentation

It was discussed that the formulation and selection of the most appropriate metric should consider a few criteria:

- The desired metrics, in order of preference, are production (i.e., APR), abundance, and biomass.
- The metrics could be developed for either single species, CRA species, or all species.

Further discussions were held around identifying meaningful differences among sites/regions in consideration of a number of variables:

- Eelgrass/bare/algae dominated sites.
- Regional variation.
- Other environmental cofactors.

From the data that was presented at the meeting it was agreed that a statement could be made about meaningful differences between sites within a single region. Alternatively, as a result of only having data from two regions, it was difficult to identify whether there were meaningful differences between regions.

It was suggested that management should be made aware that although eelgrass is a highly productive habitat it is not an indication of importance in relation to other habitats. For example, the loss of bare habitat could have undesirable consequences for flounder just as the loss of eelgrass habitat for juvenile cod

OBJECTIVE #2 - APPROPRIATE APPROACHES AND METHODOLOGIES

Other approaches to consider

A suggestion was made to use a life history approach by estimating densities of juveniles in the nearshore habitats based on the abundance of adults in the offshore habitats (e.g., by using commercial fishery data). By understanding the life history of a species you can theoretically compute the connection between the number of recruits and the number of resulting adults and vice versa.

Alternatively, a genetic approach would examine the connection between juveniles of one genotype and related adults in the offshore environment. In addition to these approaches, it was agreed that a bottom-up strategy or a habitat suitability model could also be effective at connecting nearshore to offshore populations.

Other considerations/issues

Participants suggested several other variables that could impact productivity that should be studied:

- Habitats found across different lobster fishing areas.
- Sediment grain size within in a habitat, from sand particles to boulders.
- Community impacts when 15% of a single sea grass patch is removed in contrast with 100% removal.

OBJECTIVE #3 - HABITATS/UNITS FOR THE EVALUATION OF FISH PRODUCTIVITY

It was agreed that a number of points should be considered when developing appropriate spatial units for the evaluation of fish productivity:

- The presentations given at this meeting only considered eelgrass/bare/algae habitat types.
- Community productivity assessments were not done.
- Spatial units could be defined at the habitat scale, local ecosystem scale (bays), regional scale, or ocean scale.
- Existing data should be used to estimate the potential for comparing habitats across regions.
- Estuaries and other special habitats could impact productivity differently.

Reference was made to a CSAS meeting held on September 29 – October 2, 2015 on the Evaluation of Hierarchical Marine Ecological Classification Systems for Pacific and Maritimes Regions. It was indicated that the resulting SAR (DFO, 2016a) provided some insight on an appropriate scale for the evaluation of fish productivity. Additionally, it was noted that the SAR published from the freshwater Regional Productivity Benchmarks meeting, could be used to identify some benthic features in the marine environment that inform fisheries productivity. A number of alternative datasets were also spoken about in this respect.

Other participants mentioned that oceanic circulation and salinity regimes, among other abiotic characteristics, would impact the productivity of a nearshore environment.

A discussion was held on the potential use and limitations of a software (Marxan) used in the identification of Marine Protected Areas (MPA). It was decided that the scale at which Marxan discriminates habitats (~25km) was not sufficiently small enough for use in productivity metrics.

The authors will attempt to extract relevant data from the Wong and Dowd Research Document that speaks to broad scale patterns within some regions, that impact fish productivity. The size of habitat used in this Research Document is limited to the area surveyed. Additionally, the authors will work to narrow the range of APR expressed in this Research Document (1 to 10^6 m^2) by segregating the data by study site. It is possible that the range was large as a result of incorporating data from all surveyed sites including some where outliers existed.

OBJECTIVE #4 - FEASIBILITY OF AREA PER RECRUIT APPROACH

APR is an easy-to-comprehend metric to inform management tools for a regulatory approach to decision making. This metric was originally estimated for relatively simple lake and stream ecosystems (i.e., one or few dominant species) to understand impacts on nearshore nursery habitat in terms of adults lost.

Several issues for developing benchmarks in marine environments were discussed in relation to sampling:

- In some places, many species use the same habitats.
- Small forage fish may impact productivity estimates differently than large commercially important fish.
- Some species may seem rare if sampling habitats that are not of a preferred type (e.g., eelgrass).
- Some species may be transitory users of habitat.

A participant indicated that it was easier to digest the data when it was considered in relative terms instead of absolute values of fish density, as the values appeared extreme.

Determining the APR in marine habitats was more complex than in freshwater habitats. For example, a greater number of species overlap in marine environments and have higher mortality rates. Further work is required to calculate APR for marine environments. Suggestions were given on how to proceed with the model:

- Revisiting the part of the model used to estimate survival.
- Using representative species whose life history is well known and predictable.
- Reviewing the inputs and outputs in the Wong and Dowd Research Document to be more selective about the species included.

It was argued that invasive species and others (e.g., bivalves) that were not incorporated in the Wong and Dowd model should be incorporated into future calculations of APR as they have

become a part of many Canadian ecosystems. Ultimately, it was agreed that management might focus on important habitats for native species as opposed to habitats dominated by invasives.

It seemed counterintuitive that higher APR values occurred in marine habitats, when they are likely more productive than freshwater habitats. This may be due to the inclusion of data from species that were relatively rare, resulting in low densities and high APR values. Such species may have preference for other habitats resulting in lower APR values.

NEXT STEPS AND FUTURE RESEARCH

During the discussion a number of items were identified for the SAR, the working papers, and for future research:

- Robert Gregory agreed to develop biomass estimates from his research presented at the meeting.
- Melisa Wong agreed to develop biomass estimates and regional density numbers from her research presented at the meeting.
- Melisa Wong agreed to calculate community production from the data she presented at the meeting.
- Participants requested that the uncertainties section of the SAR include:
    - Uncertainties associated with standing stock biomass. Particularly, the complexity of using this indicator for species whose life history includes significant migration.
    - Uncertainties and assumptions associated with steady-state communities.
    - An explanation of the limited understanding of the spatial variability within ecoregions. It was suggested that the Community Aquatic Monitoring Program (CAMP) time series data be used to provide some preliminary insight for this.
    - Uncertainties associated with the differences in productivity between Atlantic and Pacific habitats as a result of a lack of comparable data from the Pacific Region.
    - Uncertainties associated with the model outputs when sampling a depleted population.
    - Uncertainties associated with capture efficiency of the community (i.e., for sediment dwelling invertebrates in particular) being sampled for model inputs.
    - An explanation of the unpredictable outcomes of using data inputs from other communities after having studied and presented only nearshore habitats that are generally nursery areas.
    - A brief description of how Robert Gregory's future work will provide further insight for the following uncertainties:
        - The limited understanding of the temporal variability in the communities and habitats presented at the meeting.
        - The limited understanding of the implications of data from individual species or the whole community.

There was consensus that the Wong and Dowd working paper should be accepted as a CSAS Research Document for this meeting with the following considerations:

- There was a lack of empirical data to test/validate the model.
- Results from the model were limited to a few habitat types from the Atlantic coast of Nova Scotia.
- Benchmarks would need to be revisited and updated regularly as a result of climate change or variation in eelgrass distribution.
- The productivity model was developed with mortality models which could be validated with empirical estimates of mortality.
- Further consideration should be given to the change in productivity model outputs resulting from a number of variables:
    - Input data collected from habitats at carrying capacity.
    - Ecosystems that exhibit increased larval mortality.
    - Population impacts from entrainment.
    - Abundance or population related issues associated with aquaculture sites.

Participants agreed to review the Gregory, Laurel, and Cote, *et al.*, paper after the meeting to determine whether it could be published as a Research Document. The written feedback was then to be incorporated into the publication.

Participants suggested that future work should include the following pursuits:

- Characterization of APR in other habitats and for other species (e.g., sediment dwelling organisms in particular) than those presented at this meeting.
- Improvement of hierarchical spatial analyses and the resolution of small scale features in coastal habitats.
- Collection of data from habitats in the Pacific Region and computation of their APR using the Wong and Dowd model.
- Potential use of a Light Detection and Ranging (LiDaR) system to capture biological trends in aquatic habitats at 0-30m of depth. It was discussed briefly that this technology has improved and is significantly cheaper to use now, but is still affected by poor weather conditions and turbidity.
- Analyses of a variety of datasets using the Wong and Dowd model to better understand the variability of APR and production potential:
    - The CAMP time series data.
    - Data collected by Robert Gregory.

REFERENCES CITED

DFO. 2016a. Evaluation of Hierarchical Marine Ecological Classification Systems for Pacific and Maritimes Regions. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/003.

DFO. 2016b. Science Advice on Regional Productivity Benchmarks. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/053.

Randall, R.G., Boston, C.M., Doka, S.E., Gertzen, E.L, Mossman, J. 2014. Assessing marine criteria for Ecologically and Biologically Significant Areas (EBSA): are the criteria interpretable and measureable in Lake Ontario? Can. Sci. Advis. Sec. Res. Doc. 2014/044. v + 40 p.

Randall, R.G., Bradford, M.J., de Kerckhove, D.T., and van der Lee, A. 2017. Determining regional benchmarks of fish productivity using existing electrofishing data from rivers: proof of concept. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/018. v + 50 p.

APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Name	Affiliation
Mike Bradford **chair**	DFO Pacific / Ecosystems Sciences Division
Keith Clarke **chair**	DFO Newfoundland & Labrador / Environmental Sciences Section
Shannon Stuyt	DFO National Capital Region / Ecosystem Science
Mike Stoneman	DFO National Capital Region / Environment & Biodiversity Science
Sophie Foster	DFO National Capital Region / Canadian Science Advisory Secretariat
Lauren Ellis **editor**	DFO National Capital Region / Canadian Science Advisory Secretariat
Chantal Ménard	DFO National Capital Region / Habitat Management Policies and Practices
Robert Gregory	DFO Newfoundland & Labrador / Environmental Sciences Section
Darrin Sooley	DFO Newfoundland & Labrador / Fisheries Protection Program
Melisa C Wong	DFO Maritimes / Coastal Ecosystem Science
Mark G McLean	DFO Maritimes / Fisheries Protection Program
Guy Robichaud	DFO Gulf / Habitat Protection Branch
Chris Mckindsey	DFO Quebec / Demersal and Benthic Science Branch
Diane Lavoie	DFO Quebec / Pelagic and Ecosystem Science Branch
Jean-Yves Savaria	DFO Quebec / Fisheries Protection Division, Regulatory Reviews
Neil Mochnacz	DFO Central and Arctic / Arctic Aquatic Research Division
Karen Smokorowski	DFO Central and Arctic / Great Lakes Laboratory for Fisheries and Aquatic Sciences
Robert Randall	DFO Central and Arctic / Great Lakes Laboratory for Fisheries and Aquatic Sciences
Jacob Ziegler	DFO Central and Arctic / Ecosystem Science Branch
Kim Hyatt	DFO Pacific / Ecosystems Sciences Division

Name	Affiliation
Jackie King	DFO Pacific / Ecosystems Sciences Division
Herb Herunter	DFO Pacific / Ecosystems Sciences Division
Byron Nutton	DFO Pacific / Ecosystems Management
Jason Hwang	DFO Pacific / Oceans, Habitat and Enhancement
Brenda Rotinsky	DFO Pacific / Fisheries Protection Program
Emma Cooke **editor**	Canadian Healthy Oceans Network (CHONe) Student
Evelyn MacRobert	Canadian Healthy Oceans Network (CHONe) Student
Bruce G. Hatcher	Cape Breton University
Dominique Robert	University of Quebec at Rimouski

APPENDIX 2: MEETING TERMS OF REFERENCE

Science Advice on Marine Productivity Benchmarks

National Peer Review - National Capital Region

March 28-30, 2017
Ottawa, Ontario

Co-Chairpersons: Mike Bradford and Keith Clarke

Context

The *Fisheries Act* was amended in 2012 to include new provisions for fisheries protection which came into force in 2013. The amended Act focuses on managing threats to the sustainability and ongoing productivity of commercial, recreational or Aboriginal fisheries and contains a prohibition against serious harm to fish that are part of or support a commercial, recreational or Aboriginal fishery. Serious harm to fish is defined in the Act as the death of fish, the permanent alteration to, or destruction of, fish habitat. If serious harm to fish cannot be avoided, proponents of projects may apply for authorizations.

Although productivity is not part of determining whether serious harm to fish has occurred, Fisheries Protection Program (FPP) considers fisheries productivity, among other factors, when considering whether an authorization is appropriate (section 6, 6.1 in the *Fisheries Act*).

Building on previous advice in freshwater ecosystems on the feasibility of using regional community and population productivity benchmarks (DFO 2016), Ecosystems Management is requesting science advice on the feasibility of determining benchmarks of fish productivity in marine ecosystems, including relevant methodologies and spatial units of variability. This advice is necessary to understand regional variability in fish productivity across Canada. Once developed, regional productivity benchmarks are anticipated to be used in the following ways:

- To provide estimates of regional productivity that can be used for understanding baselines for the purposes of impact assessment in the absence of site-specific data for small-medium impact projects.
- To provide estimates of regional productivity that can be used to reasonably estimate targets of potential gains in productivity expected from offsetting.

Building on previous advice in freshwater ecosystems on the use of area per recruit (APR) estimates in setting thresholds (DFO 2015), Fisheries and Oceans Canada (DFO) Ecosystems Management is requesting advice on marine relevant estimates of Area per recruit.

Area per recruit (APR) is defined as follows:

- The area of nursery habitats in a stream or lake required to produce one adult recruit with recruits defined as reproductively mature fish.

Objectives

Participants will review Research Documents to address the following questions:

1. Is it feasible to use estimates of fisheries productivity in marine ecosystems to develop benchmarks relevant to evaluate project impacts and offsetting?
2. What approaches and methodologies would be appropriate to determine fish productivity in marine ecosystems?

3. What are the representative habitats or spatial units within which fish productivity can be evaluated, and how do they compare?
4. Is it feasible to use an area per recruit approach as a common metric for discussing impacts to habitat quantity and/or quality on Canadian marine fish?

Expected Publications

- Science Advisory Report
- Proceedings
- Research Documents

Expected Participation

- Fisheries and Oceans Canada (Ecosystems and Oceans Science, Fisheries Protection Program)
- Academia
- Other invited experts

References

DFO. 2016. Science Advice on Regional Productivity Benchmarks. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/053.

DFO. 2015. Science Guidance for Fisheries Protection Policy: Advice on Equivalent Adult Calculation. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/011.

APPENDIX 3: MEETING AGENDA

Fisheries and Oceans Canada

Canadian Science Advisory Secretariat (CSAS)
National Science Advisory Workshop

AGENDA - Science Advice on Marine Productivity Benchmarks

Co-Chairpersons: Mike Bradford and Keith Clarke

Location, Ontario Room, Lord Elgin Hotel, Ottawa, ON

March 28-30, 2017

WebEx Details: Link

Meeting Number: 553 135 095
Meeting Password: 2fEiXV35

Call-in toll-free number: 1-877-413-4785 (Canada)
Call-in number: 1-613-960-7512 (Canada)
Conference ID: 313 578 5

Tuesday, March 28th

Time	Description	Lead
9:00 – 9:30	Introduction to CSAS advisory process Review Terms of Reference	Co-Chairs
9:30 – 10:00	Overview of the Fisheries Protection Program: Potential Application of Benchmarks	Jason Hwang
10:00 – 10:30	Presentation: Determining Freshwater Regional Benchmarks of fish productivity	Bob Randall
10:30	Break	
10:45 – 11:00	Discussion: Freshwater Benchmarks Science Advice	
11:00 – 11:20	Presentation: Towards regional benchmarks of fish productivity in nearshore marine ecosystems: model framework, habitat comparisons, and examination of regional data	Melisa Wong
11:20 – 12:00	Discussion	
12:00 – 1:00	Lunch Break	
1:00 – 1:30	Presentation: Fish production metrics from a nursery area in the marine coastal zone of Newfoundland	Bob Gregory
1:30 – 2:00	Presentation: Habitat selection by juvenile cod in	Evelyn

Time	Description	Lead
	coastal marine nurseries: the role of piscivorous fish	MacRobert
2:00 – 2:30	Discussion	
2:30	Break	
2:45 – 4:30	Continued discussion	

Wednesday March 29th

Time	Description	Lead
8:30 – 9:30	Re-cap of day 1	Co-Chairs
9:30 – 10:30	Identification of key themes for the SAR Begin drafting Science Advisory Report	
10:30	Break	
10:45 – 12:00	Continue drafting Science Advisory Report	All
12:00 – 1:00	Lunch Break	
1:00 – 2:30	Continue drafting Science Advisory Report	All
2:30	Break	
2:45 – 4:30	Continue drafting Science Advisory Report	All

Thurs March 30th

Time	Description	Lead
8:30 – 10:30	Re-cap of day 2 Continue drafting SAR	Co-Chairs All
10:30	Break	
10:45 – 12:00	Drafting Science Advisory Report Wrap Up / Next Steps	Co-Chairs/ All